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CARIBBEAN FRUIT FLIES, *ANASTREPHA SUSPENSA* (LOEW) (DIPTERA: TEPHRITIDAE), REARED FROM EGGS TO ADULTS ON CANNIBALISTIC DIET

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Abstract.—In the laboratory Caribbean fruit flies, *Anastrepha suspensa* (Loew), were reared from eggs to adults on a cannibalistic diet. Starting 1 day after eclosion, larvae received as food only conspecific eggs or larvae newly eclosed from these eggs. Of one group of 20 larvae, 5 (4♂, 1♀) grew to adulthood. None in a second group of 20 larvae survived to adulthood. When fed water, sucrose and yeast hydrolysate enzymatic, the adults mated, and the female produced eggs from which at least one larva eclosed. Thus, *A. suspensa,* an herbivorous species, can develop into apparently normal adults in the absence of plant material.

Cannibalism is widespread in the animal kingdom, including a number of insect orders, and occurs normally in the field for a number of species (Fox, 1975). Herbivorous insects, as well as carnivores, engage in cannibalism (Kirkpatrick, 1957). Instances of cannibalism by herbivorous insects in the presence of abundant host plant material have been reported in nature and in the laboratory (Brower, 1961).

Although cannibalism may play a crucial role in the development, survival, and population dynamics of some insects, little is known about the development of herbivorous insects in the absence of plant material. The rearing of Caribbean fruit flies, *Anastrepha suspensa* (Loew), without fruit or artificial diet is reported here.

Materials and Methods

The insects used in this study were from a laboratory colony maintained on the artificial larval diet described by Burditt et al. (1975). Flies laid eggs through the cotton sleeves of the screened aluminum rearing cages. The eggs were brushed off on successive days with a soft bristled paint brush, so that after the first day of a series of collections, the eggs removed were ≤24 h old. The eggs were rinsed in distilled water to remove nonviable eggs and debris, and soaked for 4 min in a 5% Clorox℠ (i.e. 0.05% sodium hypochlorite) solution to protect against contamination with ovicidal microorganisms. Again the eggs were rinsed with distilled water, and then soaked in a 0.03% sodium benzoate solution. After 4 min the eggs were poured onto a strip of Masslin℠ Sports Towel wrapped around an aluminum weighing boat (6 cm diam, 1.5 cm high), so that the portion of the strip covered with eggs was over the cavity of the boat. The eggs, thus arranged, were placed in a plastic tub (7.5 cm diam, 5 cm high), which was covered with a

transparent sheet of plastic affixed with a rubber band. Larvae eclosed 3 days after oviposition.

Four days after oviposition (i.e. 1 day after eclosion) 20 first instar larvae were placed, using forceps, on another strip of Masslin℠ towel wrapped around an aluminum weighing boat. The towel was moistened with 0.03% sodium benzoate solution. Ca. 20 mg of 1- or 2-day old eggs were piled on top of the larvae. The weighing boat with the towel and insects was placed inside a plastic tub, as previously described, and this was covered with a piece of transparent plastic held with a rubber band. All eggs and larvae were maintained at 22 to 25°C and a 16:8 photoperiodic regime. Additional batches of eggs (ca. 20 mg each), all 1 or 2 days old, were added every 1 or 2 days as long as the original larvae (noticeably larger than the younger ones eclosed from eggs provided as food) lived. After 9 days the 10 remaining original larvae were divided into two groups of five each, and set up in tubs and provided eggs as described. Larvae that occasionally crawled off the strip of towel were placed back under the pile of eggs. When the first larva attained the final instar, milled vermiculite was spread on the bottom of the weighing boats and tubs as a medium for pupariation.

Three or 4 days after formation, puparia were rinsed twice with distilled water and dried for 20 min on a paper towel. The puparia were held until adult emergence in a desiccator jar kept at 23 to 29°C in a 16:8 photoperiod. Water in the bottom of the desiccator jar maintained 100% RH within the jar. The puparia were kept until adult emergence.

Adults were held in a plastic tub (7.5 cm diam, 5 cm high) covered with plastic screen held in place with a rubber band. Water, sucrose and yeast hydrolysate were provided for nourishment. One week after at least one fly of each sex had emerged, a piece of parafilm (2 cm^2) was appressed to the screen for egg deposition. One week later, a wad of moistened tissue paper was placed in a petri dish half (5 cm diam, 0.5 cm high) and the open end of the dish covered with a sheet of parafilm. This was placed in the cage (tub) for oviposition. Eggs laid through parafilm covering the petri dish were checked daily for eclosion. Adults and eggs were maintained at the same temperature and photoperiod as the puparia.

A second group of 20 1-day old larvae was divided into groups of 10 larvae each and maintained as was the first group.

As a comparison, two groups of 20 1-day old larvae were placed into plastic medicine cups (capacity ca. 25 ml) containing ca. 18 g artificial diet. Paper lids with a pin hole in them covered the cups. After 8 days milled vermiculite (ca. 8 ml) was added on top of the diet, and 2 weeks later the puparia removed. These control insects were otherwise subjected to the same maintenance procedures, temperature and relative humidities as those on the cannibalistic diet, except that adults were not held for oviposition.

Adults were dried for 24 h in ambient RH after having been stored with moist tissue in vials in freezer. Pronotal length and width of these specimens (all cannibals and 10 of each sex of controls) were measured.

Results

Of the first group of 20 larvae, 5 (4♂, 1 ♀) developed into adults (Table 1). The rate of development of the cannibals was slower than that of larvae fed the artificial diet, and mortality was much higher. The surviving female, provided a standard

Table 1. Developmental times of *A. suspensa* reared on a diet of conspecific eggs and small larvae, and on an artificial diet.

	No. Formed Puparia	Range in Days Eggs to Puparia	No. Adults	Range in Days Puparia to Adults	Range in Days Eggs to Adults
Cannibals					
Group 1[a]	8	16–23	5	13–16	29–39
Group 2	0		0		
Control	19	7–12	17	11–14	18–26

[a] Started with 20 1-day-old larvae per group, and 20 controls.

adult diet of water, sucrose and yeast hydrolysate enzymatic, laid 24 eggs. However, she laid all but 6 of the eggs through the yeast hydrolysate smeared on the screen of the cage. Attempts to remove these eggs for maintenance under higher humidity were unsuccessful. One of the eggs laid through the parafilm covering the petri dish hatched. None of the second group of larvae formed puparia, although three attained the final instar.

Adults reared on the cannibalistic diet as larvae, although smaller, did not differ greatly in size from those reared on the artificial diet. Pronotal dimensions of the cannibals were 1.75 ± 0.24 mm long, 1.65 ± 0.19 mm wide for the males and 1.8 mm long, 1.8 mm wide for the female, while those for the flies reared on the artificial diet were 1.93 ± 0.08 mm long, 1.86 ± 0.05 mm wide for males (n = 6) and 1.9 ± 0.06 mm long, 1.8 ± 0.06 mm wide for females (n = 6). The weights of the cannibals were 4 ± 0 mg ♂, 5 mg ♀, and averaged 4.5 ± 0.84 mg ♂; 6.5 ± 1.87 ♀ for the controls.

Discussion

The failure of any of the second group of larvae to develop as far as pupariation may have been due to a recurrence of an unidentified bacterial disease (T. Clark, pers. comm.), which had ravaged the stock colony several months earlier. Further evidence for disease was the scarcity of newly hatched larvae among the eggs provided as food during the last week larvae of the second group were alive.

Often larvae that crawled away from the eggs had to be replaced under the egg pile. This emigration indicates that although egg or larval cannibalism may be nutritionally adequate, the larvae did not adapt well to such a diet. Many of the larvae that died were found away from the egg mass. It is possible that as the original larvae grew and newly eclosed larvae began to feed, insufficient food was present.

It was not determined whether the larvae ate eggs or newly hatched larvae or both, or whether this food was dead or living when eaten. Microorganisms may have played an important nutritional role (Jones, 1983).

Cannibalism may be advantageous to organisms using rather ephemeral food sources such as fruit. *A. suspensa* larvae are ill equipped to search far for a second fruit should their initial fruit become depleted as a food source. Cannibalism would help to ensure that a fruit would not become overpopulated with larvae. Furthermore, cannibalism might provide the nutrition needed for larvae to complete development should their food supply become depleted or provide the nutrition needed for small larvae to move to more suitable parts of a fruit.

In an evolutionary context predacious or scavenging insects are thought by some to be ancestral to herbivores, and reversion to carnivory might take place more readily than for a carnivore to develop properly on a largely herbivorous diet (Southwood, 1973; Strong et al., 1984).

This study shows that *A. suspensa* can develop into apparently normal adults in the absence of fruit or plant derived food, and, thus, *A. suspensa* is not dependent on any chemical unique to plants for metamorphosis.

Literature Cited

Brewer, L. P. 1961. Experimental analyses of egg cannibalism in the Monarch and Queen butterflies, *Danaus plexippus* and *D. gilippus berenice*. Physiol. Zool. 34: 287–296.

Burditt, A. K., Jr., F. Lopez, L. F. Steiner, D. L. von Windeguth, R. Baranowski, and M. Anwar. 1975. Application of sterilization techniques to *Anastrepha suspensa* Loew in Florida, United States of America, pp. 93–101. *In* Proc. Sterility Principle for Insect Control 1974. IAEA, Vienna. 622 pp.

Fox, L. R. 1975. Cannibalism in natural populations. Ann. Rev. Ecol. Syst. 6: 87–106.

Jones, C. G. 1983. Microorganisms as mediators of resource exploitation, pp. 53–99. *In* P. W. Price, C. N. Slobodchikoff and W. S. Gaud, eds., A new ecology: Novel approaches to interactive systems. John Wiley and Sons, New York.

Kirkpatrick, T. W. 1957. Insect life in the tropics. Longmans, London, 311 pp.

Southwood, T. R. E. 1973. The insect/plant relationship—an evolutionary perspective. Symp. R. Entomol. Soc. London 6: 3–30.

Strong, D. R., J. H. Lawton, and T. R. E. Southwood. 1984. Insects or plants: Community patterns and mechanisms. Harvard Univ. Press, Cambridge, Mass. 313 pp.